RD INSTRUMENTS

FOR RESEARCH AND DEVELOPMENT

INSTRUCTION MANUAL

for

AC VACUUM TUBE VOLTMETER MODEL 1602

THE HICKOK ELECTRICAL INSTRUMENT COMPANY · 10514 Dupont Avenue, Cleveland 8, Ohio

AC VACUUM TUBE VOLTMETER MODEL 1602

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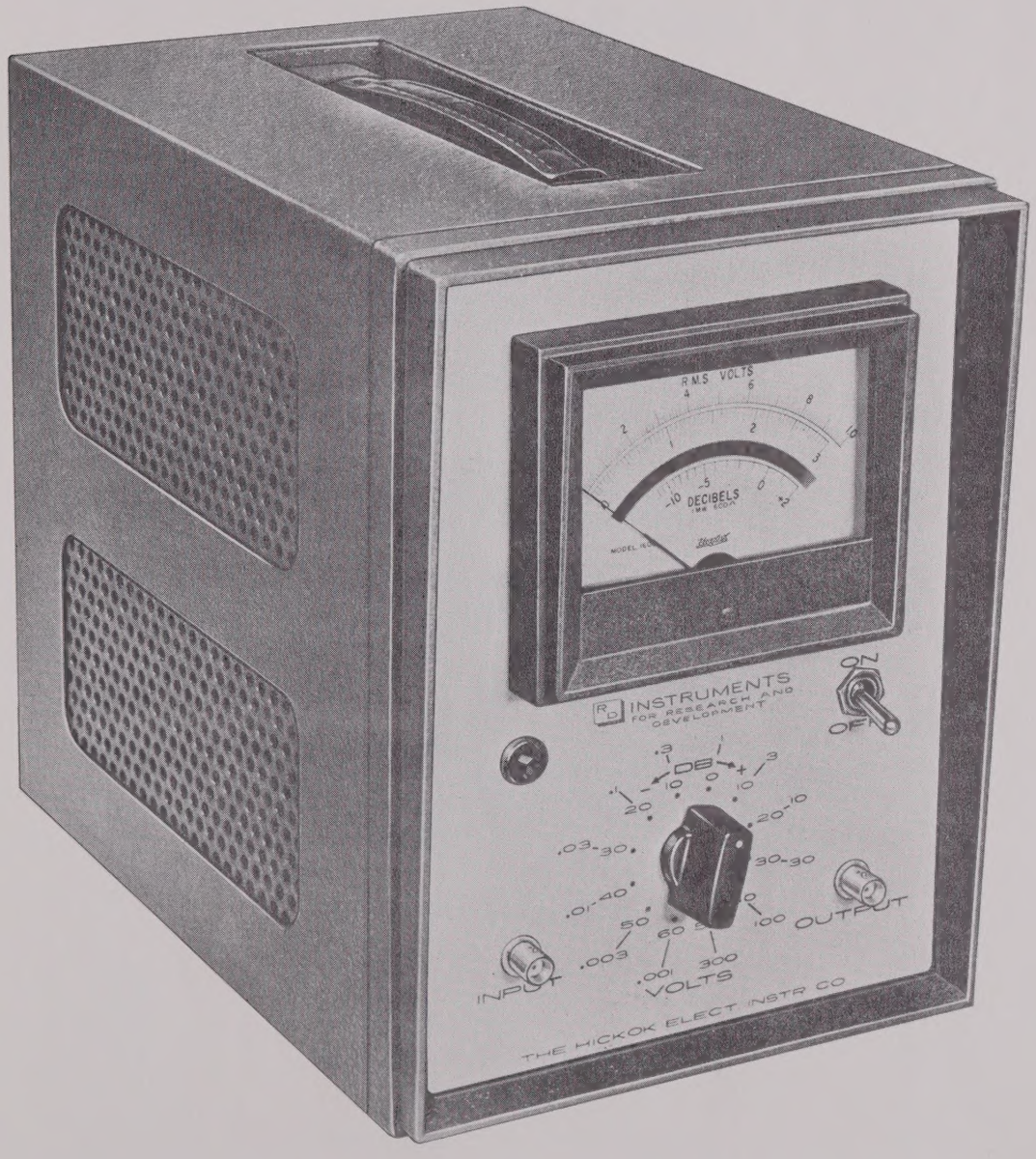
10514 Dupont Avenue - Cleveland, Ohio


R.M.S. VOLTS
DECIBELS
INSTRUMENTS
FOR RESEARCH AND DEVELOPMENT
ON
OFF
DB
.03-30
.01-40
.003
.001
VOLTS
INPUT
OUTPUT
THE HICKOK ELECT INSTR CO

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STANDARD EIA GUARANTEE

The Hickok Electrical Instrument Company warrants instruments manufactured by it to be free from defective material or factory workmanship and agrees to repair such instruments which, under normal use and service, disclose the defect to be the fault of our manufacturing. Our obligation under this warranty is limited to repairing any instrument or test equipment which proves to be defective, when returned to us transportation prepaid, within 90 days from the date of original purchase, and provided the serial number has been made known to us promptly for our records.

This warranty does not apply to any of our products which have been repaired or altered by unauthorized persons or service stations in any way so as, in our judgment, to injure their stability or reliability, or which have been subject to misuse, negligence, or accident, or which have had the serial number altered, effaced or removed. Neither does this warranty apply to any of our products which have been connected, installed, or adjusted otherwise than in accordance with the instructions furnished by us. Accessories, including all vacuum tubes not of our manufacture, used with this product are not covered by this warranty.

This warranty is in lieu of all other warranties expressed or implied, and no representative or person is authorized to assume for us any other liability in connection with the sale of our products.

Parts will be made available for a minimum period of five years after the manufacture of this equipment has been discontinued. Parts include all materials, charts, instructions, diagrams, accessories, etc., which have been furnished in the standard model.

RETURNING EQUIPMENT FOR REPAIR

Before returning any equipment for service, under warranty or otherwise, the factory must first be contacted giving the nature of the trouble. Instructions will then be given for either correcting the trouble or returning the equipment. Upon authorization, this equipment should be forwarded directly to the Hickok factory address, 10636 Leuer Avenue, Cleveland, Ohio, or to a designated service station in your locality. All correspondence pertaining to repairs should be directed to the Hickok office address, 10514 Dupont Avenue, Cleveland 8, Ohio, or to the authorized service station designated.

REGISTRATION CARD

The above guarantee is contingent upon the attached registration card being returned to the factory immediately upon receipt of the equipment.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
Cleveland, Ohio

TECHNICAL DATA

HICKOK MODEL 1602 AC VACUUM TUBE VOLTMETER

1. Power Supply Required: 115 or 230 Volts ± 10%

2. Power Consumption: 85 watts at 115 volts

3. Voltage Ranges: 12 ranges having full scale values of .001, .003, .010, .030, .100, .300, 1.0, 3.0, 10, 30, 100 and 300 volts

4. Decibel Ranges: 12 ranges having nominal scale values of -60, -50, -40, -30, -20, -10, 0, +10, +20, +30, +40 and +50 Db. Each Db range will indicate a variation of -12 to +2 Db from nominal, based on 0 Db = 1 MW in 600 ohms.

5. Frequency Response: ± 5% from 10 cps to 4 mcs, ± 2%, 20 cps to 1 MC, ± 1%, 50 cps to 500KC.

6. Input Impedance: 10 megohms shunted by 15 mmf on ranges from 1.0 to 300 volts, 10 megohms shunted by 25 mmf on ranges from .001 to .3 volts.

7. Amplifier Output: Output terminals are provided to permit use of the Model 1602 as an amplifier over its frequency range. The output voltage will be approximately 0.15 volt RMS for an input giving full scale meter deflection on any range.

8. Tube Complement:

Quan.	Type	Function
2	6DE6	Input Cathode Follower and Amplifier Input
3	6CB6	Amplifier
1	6AX5	Rectifier
1	12B4A	Series Regulator
1	6U8A	Error Amplifier
1	5651	Reference Tube

SECTION I - DESCRIPTION

1.1 Purpose

The Model 1602 is a stable and sensitive AC Vacuum Tube Voltmeter capable of accurately measuring AC Voltages over a range of 0.001 to 300 volts full scale and 10 cps to 4 mcs, and decibels from -72 to +52 db.

The characteristics of this instrument make it useful for audio, video and RF measurements over a wide range of voltages and frequencies. The Model 1602 may also be used as an amplifier to give increased sensitivity to bridges, oscilloscopes and other instruments.

1.2 Description

The Model 1602 is enclosed in an aluminum case with a recessed handle on top and four rubber feet on the bottom. The chassis and front panel are assembled as a unit making the instrument accessible for servicing by the removal of two (2) screws in the back of the case. Two BNC coaxial receptacles are provided on the front panel for input and output connections.

SECTION II - THEORY OF OPERATION

2.1 General

The Model 1602 circuit consists of an input attenuator, a wide band amplifier, a metering circuit and a regulated power supply. A block diagram of the circuit is shown in Figure 2.1.

The voltage to be measured is applied to the input terminals of the voltmeter and consequently to the cathode follower attenuator. On the low ranges (.001 to .3 volt) the signal is connected to the grid of the cathode follower with the range in use selected by a 6 step voltage divider in the cathode. On the high ranges (1.0 to 300 volts) the input signal is attenuated by a 1000 to 1 divider in the grid circuit, and the range in use again selected by the 6 step cathode circuit voltage divider. The output from the cathode divider is coupled to a broadband amplifier.

The amplifier output is connected to a full wave bridge rectifier and then to the DC indicating meter. The current flowing through the meter is proportional to the average value of the input voltage, and the meter is calibrated to indicate the RMS value of a sine wave input voltage.

2.2 Input Attenuator

The input attenuator consists of a two-step resistive voltage divider connecting the input signal to the grid of tube V101 with attenuation ratios of 1 : 1 and 1000 : 1 and a six-step voltage divider in the cathode of tube V101, which is operated as a cathode follower. Proper connections to the two dividers are arranged in the Range Switch to provide the twelve voltage and Db ranges of the instrument.

2.2.1 Two-step Voltage Divider

When the Range Switch is on any of the six lowest ranges (.001 to .3 volts) section S1A of the Range Switch connects the input signal directly (1 : 1 ratio) to the grid of cathode follower tube V101. When the Range Switch is on any of the six highest ranges, (1.0 to 300 volts) the input signal is connected from the junction of R103 and R101 to the grid of V101 by switch section S1A providing a 1000 : 1 voltage divider ratio.

2.2.2 Six-Step Voltage Divider

Six voltage divider ratios are provided in the cathode circuit of tube V101 by resistances R110 A and B and R111 A, B, C and D. The six taps of the cathode resistor are connected to the grid of V102 by proper connections on Range Switch section S1B. The range switch sweeps twice through the six steps in switching through the full range of the instrument. On the six lowest ranges the 1 : 1 divider is connected in the grid circuit, and on the six highest ranges the 1000 : 1 divider is connected in the grid providing a total of twelve ranges.

Output from Cathode follower V101 is connected to the grid of V102, the first amplifier stage. Gain of the amplifier is adjusted to give full scale meter deflection with a .00095 volt signal at the grid of V102. The voltage dividers in the grid and cathode circuits of cathode follower V101 provide this voltage on all ranges.

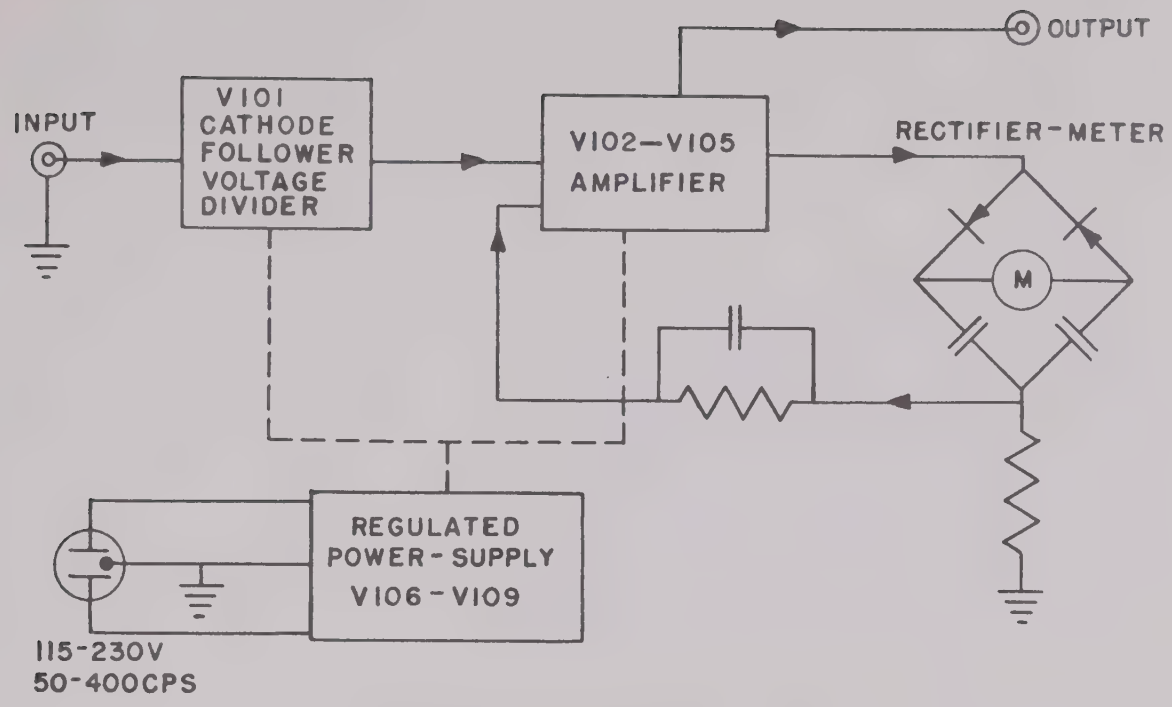
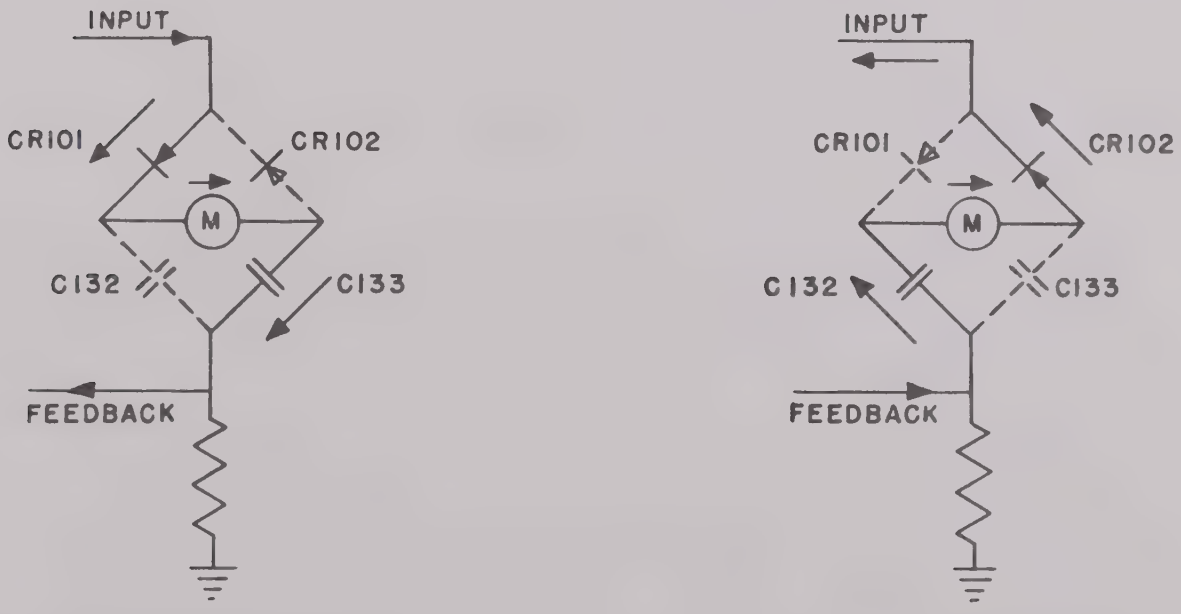


FIG 2.1 BLOCK DIAGRAM MODEL 1602
AC VACUUM TUBE VOLTMETER



A. POSITIVE HALF CYCLE

B. NEGATIVE HALF CYCLE

FIG 2.2 CURRENT FLOW IN BRIDGE CIRCUIT

Resistance-Capacitance coupling networks in the cathode circuit of V101 reduce transients due to range switching. Trimmer capacitors C138 on the .01/10 volt and C137 on the .003/3 volt ranges provide high frequency compensation for the divider. Trimmer capacitor C102 in the two step grid circuit divider provides compensation for stray capacitance, keeping the divider ratio constant over the full frequency range.

2.3 Amplifier

The amplifier consists of four resistance capacitance coupled stages. Interstage coupling networks provide frequency compensation and separate low and high frequency coupling, resulting in a flat response over a wide frequency range. Gain of the amplifier between the grids of V102 and V105 is approximately 55-60 Db over the 10 cps to 4 mcs frequency range. A high percentage of negative feedback along with plate circuit compensation and cathode degeneration result in a highly stable wide band amplifier. Degenerative feedback from the plate of V105 through the rectifier-meter circuit is applied to the cathode of V102. The amount of feedback and resulting gain is adjusted by resistor R135 in the feedback loop. Trimmer capacitor C119 in the feedback loop adjusts the high frequency response of the amplifier. Tube V105 operates as an amplifier to drive the bridge rectifier and meter, as well as a cathode follower to supply voltage to the output terminals of the instrument when used as an amplifier. The output impedance of the amplifier is approximately 50 ohms.

2.4 Rectifier and Meter

The rectifier and meter are connected in a full wave bridge circuit, with a crystal diode and capacitor in each branch, and the meter connected across the bridge midpoints. The bridge functions as a full wave rectifier of the input current, providing a pulsating direct current to the meter, and recombining the pulsations to provide a sine wave current to the feedback loop of the same frequency as at the input to the bridge. Current through the meter is proportional to the average value of the instrument input voltage, with the calibration in terms of the RMS value of a sine wave input. Therefore an input voltage with a non-sinusoidal waveform will produce erroneous voltage readings. Current flow through the bridge is shown in figure 2.2.

During the positive half cycle, the effective current flow is from the input through diode CR101, meter M and capacitor C133 to the feedback loop. During the negative half cycle the effective current flow is from the feedback loop through capacitor C132, Meter M and diode CR102 to the bridge input.

Current flow through capacitor C132 on positive half cycles and C133 on negative half cycles shunts the meter circuit reducing the bridge efficiency. Use of these capacitors in place of the rectifiers of the conventional bridge improves the linearity and response of the circuit over a wide frequency range. The resulting function of the bridge provides a unidirectional current flow through the meter, and an alternating current flow through the feedback loop.

2.5 Power Supply

The power supply operates from a source of 115 ± 10% or 230 ± 10%, 50 - 400 cps power. It provides regulated high voltage DC for the tube plate circuits, unregulated DC filament voltage for tubes V101 through V104 and AC filament voltage for the remainder of the tubes.

The high voltage supply consists of rectifier V106, series regulator V107, reference voltage source V109 and error amplifier V108.

The DC filament voltage is furnished by selenium rectifier SR1 and filtered by capacitors C142 and C143. Output voltage is adjusted by resistor R174.

SECTION III - OPERATING INSTRUCTIONS

3.1 General

The Model 1602 is thoroughly calibrated and inspected prior to shipment and should be in proper working order after being removed from the protective packing. Thoroughly inspect the packing, carton and materials to be sure all papers and accessories have been removed. Examine the instrument for damage which may have occurred during shipment. If such damage has occurred, refer to the instructions on the damage report sheet enclosed with the instrument.

The power transformer primary circuit is connected for 115V ± 10%, 50-400 c ps operation at the factory. If 230V ± 10% operation is desired, reconnect the transformer as shown in the schematic diagram.

Plug the AC power cord into a receptacle supplying voltage as required above. Turn the power switch to ON and permit the instrument to warm up for at least 5 minutes.

3.2 Voltage Measurements

Set the range switch to the voltage range desired. Connect the voltage being measured to the input terminal. If the magnitude of the voltage is unknown set the range switch to the highest voltage range before connecting the input voltage. Then reduce the range until a suitable deflection is obtained on the meter. Read the voltage on the appropriate scale according to the range selected.

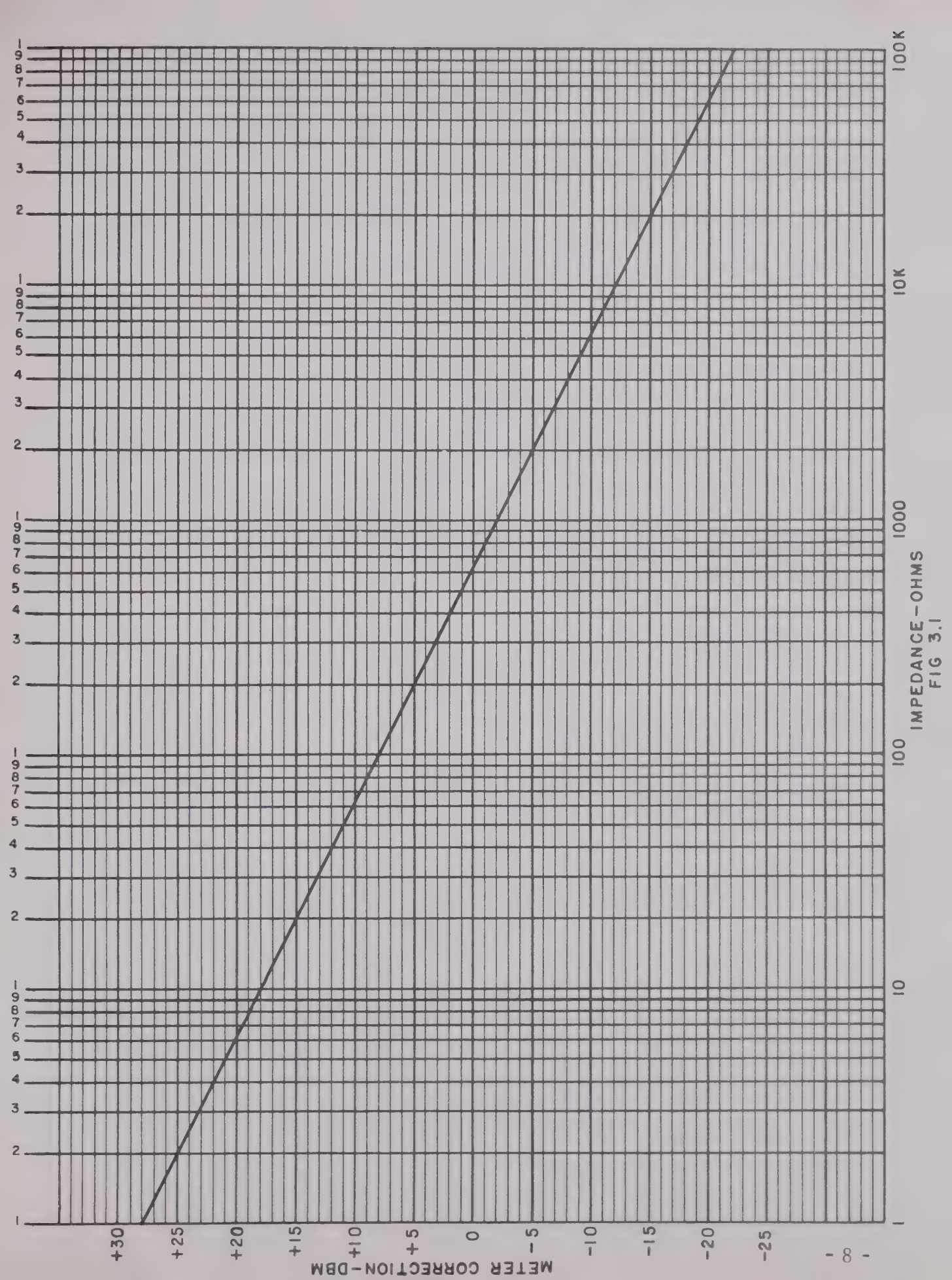
3.3 Decibel Measurement

Set the range switch to the decibel range desired. If the magnitude of the voltage is unknown, set the range switch to the highest range and reduce the range until a suitable reading is obtained. Connect the unknown voltage to the input terminal. Read the decibel level as the sum of the indication on the meter scale and the setting of the range switch in decibels.

The decibel indication is correct as indicated only when measuring across a 600 ohm source impedance. To obtain correct level measurements across other impedances, add or subtract the correction factors as shown on the graph of Figure 3. 1.

3.4 Amplifier

A voltage proportional to the input voltage and having an open circuit amplitude of approximately 0. 15 volts for a full scale meter deflection is available at the Output terminal. The amplifier response is essentially flat from 10 cps to 4 mcs. Output impedance of the amplifier is approximately 50 ohms. With a 50 ohm load across the output terminals, the output voltage will be approximately . 075 volts, increasing to the open circuit value as the impedance of the load is increased.


100K
10K
1000
100
10
1
IMPEDANCE-OHMS
FIG 3.1
+30
+25
+20
+15
+10
+5
0
-5
-10
-15
-20
-25
METER CORRECTION-DBM

SECTION IV - MAINTENANCE

4.1 General

The Model 1602 is built in accordance with sound engineering principles, by skilled personnel, using quality components.

Normally, routine replacement of tubes will be the only field maintenance necessary. This section contains information for maintaining, trouble shooting and making internal adjustments on the instrument. Should the need arise for more extensive maintenance, it is suggested that the factory be contacted with regard to the nature of the trouble, and if necessary, the unit be returned to the factory or authorized repair station for service.

Access to the interior of the instrument may be had by removing the two screws at the rear of the case and sliding the front panel and chassis out the front of the case.

4.2 Tube Replacement

In the event of tube failure, tubes used for replacement should be aged in place for at least 24 hours before checking and calibration are undertaken.

When replacing tubes with new ones, if the difficulties are not corrected, return the old tube to its socket. Do not interchange tubes in their sockets. After replacing any of the amplifier tubes the calibration should be checked and after replacing any of the H.V. DC regulator tubes the DC Voltage should be checked. Adjustments in either case being made as necessary. DC filament voltage should also be checked and adjusted ad required.

4.3 Calibration

a. Connect a low distortion oscillator and accurate AC Voltmeter (1/2% FS) to the input terminal.

b. Apply .001 volt 400 cps on the .001 volt range and adjust R135 until the meter reads exactly full scale.

c. With capacitor C102 set to approximately half capacitance, apply a .001V signal on the .001V range at 5 mcs to the instrument. Adjust capacitor C119 until the meter reads exactly full scale.

d. Repeat "c" using a frequency of 3 mcs and adjust C126 until the meter reads exactly full scale.

e. Repeat steps "c" and "d" until the response curve is flat from 3 mcs to 5 mcs. Check frequency response across the full range, 10 cps to 5 mcs.

f. Apply a .030V signal at 4 mcs to the .030V range of the voltmeter. Adjust capacitor C145 for a full scale reading.

g. Apply a signal of 1.0V at 400 cps to the 1.0V range of the instrument. Adjust the value of resistor R106 until the meter reads full scale. Adjustment is made by changing the value of the padding resistor across R106.

h. Increase the frequency of the oscillator to 500 Kcs and maintain the voltage at 1.0 volt. Adjust capacitor C102 until the meter reads full scale.

i. Increase the oscillator frequency to 4 mcs maintaining the output at 1.0 volt. Adjust capacitor C102 until the meter reads full scale.

j. Set the oscillator to 500 kcs and adjust the output to .003V. Adjust capacitor C137 to give full scale deflection of the meter on the .003V range.

k. Apply a 500 Kcs signal of .010V amplitude to the meter and adjust capacitor C138 for a full scale meter reading on the .010 volt range.

The instrument should now be calibrated for both voltage and frequency response over its full range.

4.4 Troubleshooting

Should the Model 1602 fail to function properly, the trouble can best be located by first checking the major functional sections of the circuit and then checking the individual stages of each section.

A typical sequence of checking would be:

A. Power Supply. - With 115V line

1. B+ Voltage 250V
2. DC Filament Voltage 12.6V

B. Amplifier Gain. - With exactly 0.3 volt, 400 cps input and full scale deflection, output voltage should be .150 ± 10% Volts.

C. Tubes. - Check instrument tubes by replacing with tubes known to be good. If the replacement tube does not improve the operation, return the original tube to the socket and continue with the next.

D. Components. - If the above tests do not locate the trouble, components must be checked stage by stage. A voltage resistance and chart is provided to assist in this check. Figure 4.1.

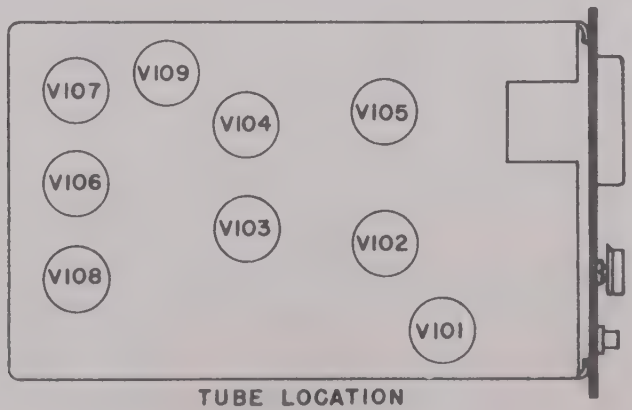
E. Frequency Response. - Should the frequency response be down excessively at either or both ends of the frequency range and tube replacement does not correct it, the instrument should be returned to the factory for repair.

VOLTAGE AND RESISTANCE TABLE

		SOCKET PIN								
		1	2	3	4	5	6	7	8	9
V101	Volts	+54	+58	0	+6.3	+165	+165	+165		
6DE6	Res	10.1M	6.5K	0	3	150K	150K	150K		
V102	Volts	0	+1.6	0	+6.3	+120	+115	+1.6		
6DE6	Res	750K	135	0	3	155K	185K	135		
V103	Volts	0	+1.5	+12.6	+6.3	+120	+115	+1.5		
6CB6	Res	510K	0	5	3	170K	185K	0		
V104	Volts	0	+1.5	+12.6	+6.3	+120	+115	+1.5		
6CB6	Res	510K	120	5	3	170K	185K	120		
V105	Volts	+0.6	+2.1	.5AC	6.8AC	+130	+115	+2.1		
6CB6	Res	430K	171	5.5	5.5	165K	185K	171		
V106	Volts		+125	420AC		420AC		+125, 6.3AC	+400	
6AX5	Res	NC	135K	150	NC	150	NC	130K	80K	
V107	Volts	+250	+232	+125, 6.3AC	+125	+125	+232	+232	+16	+415
12B4A	Res	50K	380K	130K	132K	132K	380K	440K	0	80K
V108	Volts	+250	+90	+133	+125, 6.3AC	+125	+232	+90	+90	+85
6U8A	Res	65K	90K	40K	132K	132K	400K	18K	18K	200K
V109	Volts	+85	0		0	+85				
5651	Res	500K	0	NC	0	500K	NC	NC		

Measurements taken with no input or output connections, 115V Line Voltage, 100 Megohm Vacuum Tube Voltmeter, and Range Switch on 300 Volt Position.

Fig. 4.1



TUBE LOCATION

Symbol	Description	Code No.
C103, 104, 113, 114, 120, 125, 130, 139	CAPACITOR, Electrolytic, 20-20-20-20 mfd, 450V	3085-38
C135	CAPACITOR, Electrolytic, 50 mfd, 50V	3085-137
C142, 143	CAPACITOR, Electrolytic, 1500-1500 mfd, 15V	3085-138
C117	CAPACITOR, Electrolytic, 8 mfd, 30V	3085-139
C134	CAPACITOR, Electrolytic, 4 mfd, 60V	3085-140
C118	CAPACITOR, Mica, 180 mmf, 500V, 10%	3095-58
C121	CAPACITOR, Mica, 680 mmf, 500V, 10%	3095-66
C126	CAPACITOR, Mica, 27 mmf, 300V, 5%	3095-101
C128	CAPACITOR, Mica, 8200 mmf, 500V, 10%	3095-130
C123	CAPACITOR, Mica, 1800 mmf, 500V, 10%	3095-131
C106	CAPACITOR, Silver Mica, 4700 mmf, 500V, 5%	3095-132
C132, 133	CAPACITOR, Paper, 1 mfd, 400V	3105-300
C129	CAPACITOR, Paper, 1 mfd, 200V	3105-301
C101	CAPACITOR, Paper, .047 mfd, 600V	3105-302
C124	CAPACITOR, Paper, 2 mfd, 200V	3105-303
C107, 108, 109, 110, 111, 112	CAPACITOR, Paper, .051 mfd, 600V, 5%	3105-304
C115, 122, 127, 140	CAPACITOR, Paper, .5 mfd, 400V	3105-224
C116	CAPACITOR, Paper, .033 mfd, 600V	3105-305
C136	CAPACITOR, Ceramic, 10 mmf, 5%, 500V	3110-126
C105, 141	CAPACITOR, Ceramic Disc, .01 mfd	3110-127
C102	CAPACITOR, Ceramic Trimmer, 1.5-7 mmf, NPO TC	3115-16
C119, C137, 138	CAPACITOR, Ceramic Trimmer, 7-45 mmf, N500 TC	3115-21
R135	POTENTIOMETER, 50 ohm, 2 w	16925-394
R174	POTENTIOMETER, 4 ohm, 1 w	16925-395
R107	RESISTOR, 10 ohm, 1/2 w, 10%	18410-102
R114	RESISTOR, 27 ohm, 1/2 w, 10%	18410-272
R102, 125, 127, 142, 151	RESISTOR, 47 ohm, 1/2 w, 10%	18410-472
R108	RESISTOR, 100 ohm, 1/2 w, 10%	18411-102
R113	RESISTOR, 150 ohm, 1/2 w, 10%	18411-152
R132	RESISTOR, 270 ohm, 1/2 w, 10%	18411-272
R177, 165	RESISTOR, 470 ohm, 1/2 w, 10%	18411-472
R115	RESISTOR, 4700 ohm, 1/2 w, 10%	18412-472
R178	RESISTOR, 10K ohm, 1/2 w, 10%	18413-102
R112	RESISTOR, 24K ohm, 1/2 w, 10%	18413-241
R171	RESISTOR, 100K, 1/2 w, 5%	18414-101
R153	RESISTOR, 430K ohm, 1/2 w, 5%	18414-431
R161, 169	RESISTOR, 470K ohm, 1/2 w, 10%	18414-472
R143	RESISTOR, 510K ohm, 1/2 w, 5%	18414-511
R125, 126	RESISTOR, 560K ohm, 1/2 w, 10%	18414-562
R116, 117, 118, 119, 120, 121, 140, 141	RESISTOR, 750K ohm, 1/2 w, 5%	18414-751
R149, 150	RESISTOR, 1M ohm, 1/2 w, 10%	18415-102
R126, 128	RESISTOR, 2.7M ohm, 1/2 w, 10%	18415-272
R175	RESISTOR, 10 ohm, 1 w, 10%	18420-102

Symbol	Description	Code No.
R173	RESISTOR, 33M ohm, 1 w, 10%	18420-332
R158	RESISTOR, 51M ohm, 1 w, 5%	18420-511
R144, 152, 157	RESISTOR, 120M ohm, 1 w, 10%	18421-122
R176	RESISTOR, 270M ohm, 1 w, 10%	18421-272
R139, 148	RESISTOR, 2400M ohm, 1 w, 5%	18422-241
R155	RESISTOR, 3300M ohm, 1 w, 10%	18422-332
R172	RESISTOR, 18K ohm, 1 w, 10%	18423-182
R122, 136, 145, 154	RESISTOR, 47K ohm, 1 w, 10%	18423-472
R170	RESISTOR, 56K ohm, 1 w, 10%	18423-562
R166	RESISTOR, 68K ohm, 1 w, 10%	18423-682
R109	RESISTOR, 110K ohm, 1 w, 5%	18424-111
R162	RESISTOR, 120K ohm, 1 w, 5%	18424-121
R101	RESISTOR, 220K ohm, 1 w, 10%	18424-222
R164	RESISTOR, 330K ohm, 1 w, 10%	18424-332
R105, 123, 137 138	RESISTOR, 8200 ohm, 2 w, 10%	18432-822
R156	RESISTOR, 10K ohm, 2 w, 10%	18433-102
R146, 147	RESISTOR, 27K ohm, 2 w, 10%	18433-272
R163	RESISTOR, 180K ohm, 2 w, 10%	18434-182
R130	RESISTOR, wire wound, 125 ohm, 2 w, 10%	18575-282
R131	RESISTOR, carbon film, 71.16 ohm, 1/2 w, 1%	18537-177
R171	RESISTOR, carbon film, 100K ohm, 1 w, 1%	18539-8
R167	RESISTOR, carbon film, 181K ohm, 1 w, 1%	18539-36
R103	RESISTOR, carbon film, 10.3M ohm, 1 w, 1%	18539-37
R106	RESISTOR, carbon film, 10.31K ohm, 1 w, 1%	18539-38
R124	RESISTOR, carbon film, 8200 ohm, 1 w, 5%	18550-177
R160	RESISTOR, wire wound, 6300 ohm, 10 w, 10%	18575-280
R111A, B, C, D	RESISTOR, wire wound	18577-204
R110A, B	RESISTOR, wire wound	18577-205
R134	RESISTOR, wire wound, 205 ohm	18577-206
R159	RESISTOR, wire wound, 10 ohm	18577-207
M101	METER, 1 MA	680-177
L101	CHOKE, 15μh	3250-68
CR101, 102	CRYSTAL, 1N82A	3870-54
F1	FUSE, 1A, 3AG Slo-Blo	6900-5
I1	LAMP, #51	12270-22
SR1	SELENIUM RECTIFIER, full wave bridge	18150-63
S2	SWITCH, toggle, SPST	19911-63
S1	SWITCH, rotary	19912-468
T101	TRANSFORMER, power	20800-255
V106	TUBE, 6AX5GT	20875-88
V108	TUBE, 6U8A	20875-118
V109	TUBE, 5651	20875-158
V107	TUBE, 12B4A	20875-172
V103, 104, 105	TUBE, 6CB6	20875-186
V101, 102	TUBE, 6DE6	20875-193

ALT	DRAWING NUMBER
	976 W

INPUT

R101 220K 1W
R102 47
C101 .047
R103 10.3M 1W
C102 1.5-7 PF
R106 10.3K 1W
R107 4.2 *
R108 100
R109 110K 1W
C104 20
C105 .01
C106 4700PF
SIA

V101 6DE6
R177 470
R178 10K
C144 .75PF
C103 40 (20X20)
R105 8200 2W

R110A 4306.1
R110B 1365.7
R111A 432.26
R111B 136.74
R111C 43.24
R111D 20
R112 24K *
R113 150
R114 27
R115 4700
C145 *
C107 .051
C108 .051
C109 .051
C110 .051
C111 .051
C112 .051
R116 750K
R117 750K
R118 750K
R119 750K
R120 750K
R121 750K

SI-A-B-C

POS.	DB	VOLTS
1	-60	.001
2	-50	.003
3	-40	.01
4	-30	.03
5	-20	.1
6	-10	.3
7	0	1
8	+10	3
9	+20	10
10	+30	30
11	+40	100
12	+50	300

C136 10PF
SIC
SIB
C137 7-45PF
C138 7-45PF

R122 47K 1W
R123 8200 2W
C113 20
C114 40 (20X20)
R124 8200 2W
C115 .5
R125 560K
R126 560K
C116 .033

V102 6DE6
R125 47
R126 2.7M *
R127 47
R128 2.7M *
R129 3.3M *
R130 125 2W
C117 8
C118 180PF *
R131 71.16
R132 270 *
R133 10
R134 205
R135 50-2W
C119 7-45 PF

R136 47K 1W
R137 27K 2W
R138 27K 2W
C120 20
L101 15μH
C121 680PF
R139 2400 1W
C122 .5
R140 750K
R141 750K
C123 1800PF

V103 6CB6
R142 47
R143 510K
R144 120 1W
C124 2

R145 47K 1W
R146 27K 2W
R147 27K 2W
C125 20
C126 27PF *
R148 2400 1W
R149 1M
C127 .5
R150 1M
C128 8200PF

V104 6CB6
R152 120 1W
C129 1

R154 47K 1W
R155 3300 1W
C130 20
C131 20
R156 10K 2W
R151 47
R153 430K
R157 120 1W
C134 4
R158 51 1W

V105 6CB6
CR101 1N82A
CR102 1N82A
C135 50
C132 1
C133 1
OUTPUT
R159 10

(REG) B+ 250V

PRIMARY CONNECTIONS FOR 115/230 VOLT CONVERSION

1. 115 V OPERATION
   JUMPERS BETWEEN 1&2, 3&4
   2&3 OPEN
2. 230V OPERATION
   JUMPER BETWEEN 2&3
   1&2 OPEN, 3&4 OPEN

FUSE F1-1A
S2 ON
P1
115V AC
230V AC
115V AC

V106 6AX5
420 VAC
420 VAC
C139 40
6.3VAC
V106
V107
V108
7.3 VAC
I1
6.3VAC
V105
R173 33-1W
R174 4-1W
R175 10-1W
SR1
+12.6 DC

V107 12B4A
R160 6300 10W

R161 470K
R162 120K 1W
R163 180K 2W
R164 330K 1W
R165 470
C140 0.5
R167 181K 1W
V108B 6U8
V108A 6U8
R166 68K 1W
R168 100K
C141 0.01
V109 5651
R169 470K
R170 56K 1W
R171 100K 1W
R172 18K 1W

V103
6.3 V DC
V104
C142 1500
C143 1500
V101
V102
R176 270 * 1W
CAUTION SEE NOTE 4

NOTES:

1. UNLESS OTHERWISE SPECIFIED RESISTORS ARE 1/2W AND SHOWN IN OHMS. K=1,000 M=1,000,000
2. UNLESS OTHERWISE SPECIFIED CAPACITORS ARE IN MICROFARADS.
3. ▭ INDICATES EQUIPMENT PANEL MARKING.
4. R176 MUST BE USED IF V101 & V102 ARE 6DE6'S
   R176 MUST BE REMOVED IF V101 & V102 ARE 6CB6'S
5. * ADJUST AT FACTORY FOR OPTIMUM PERFORMANCE
   AVERAGE PART SHOWN, PART MAY BE OMITTED

NO.	ALTERATION	BY	APP'D	DATE

SCHEMATIC WIRING DIAGRAM - MOD. 1602
VACUUM TUBE VOLTMETER

DRAWN & TRACED	CHECKED	APP'D	DATE
T. BERG			2-28-61

DRAWING NUMBER 976 W

THE HICKOK ELECTRICAL INSTRUMENT CO.
CLEVELAND, OHIO

K.C.

Earl T Letts

C. E.
9654